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# EARLY DEVELOPMENT OF THE GRUBBY, *MYOXOCEPHALUS AENAEUS* (MITCHILL)[1]

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The grubby, *Myoxocephalus aenaeus* (Mitchill) is a sculpin found from New Jersey north to the Gulf of St. Lawrence (Bigelow and Schroeder, 1953; Needler, 1940; and Jeffers, 1932) and Newfoundland (Ennis, 1969). It inhabits the inshore waters and occurs in water from low tide mark to about 15 fathoms throughout the year (Summer, Osburn and Cole, 1911). Bigelow and Schroeder (1953) report the grubby as common along the shores of the Gulf of Maine and at least one specimen was taken in water as deep as 28 fathoms. Jordan and Evermann (1898) state the grubby is common in seaweeds and Dexter (1944) reports observing it inshore over hard sand and rocky bottoms.

The grubby spawns all winter throughout most of its range. Summer, Osburn and Cole (1911) report finding this true in Buzzards Bay, Massachusetts, and Bigelow and Schroeder (1953) say the same for the Gulf of Maine. Ennis (1969) believes that spawning probably occurs between late fall and early winter around Newfoundland as no egg masses had been found during winter diving. Richards (1959) reports observing 5 to 6 mm larvae in the shallower areas of Long Island Sound from February to April, and Morrow (1951) tells about spawning of the grubby during the winter months in Long Island Sound.

The eggs and larvae of *Myoxocephalus aenaeus* have never been described. Wheatland (1956) says that it is impossible to distinguish larvae of *Myoxocephalus* spp. until the fins are differentiated. Larval descriptions have been given for *M. scorpius* by Ehrenbaum (1904) but nothing is available for *M. aenaeus* except Perlmutter's (1939) sketch of a 6 mm larvae. The objective of this paper is to describe the early development of *M. aenaeus* and to contribute information on its early life history.

## Materials and Methods

Adult grubbys were collected on various dates from December through March in the Mystic River at Groton, Connecticut, with a 50-foot, knotless-nylon seine and were taken to the laboratory where they were maintained in continuous-flow aquariums. Eggs were artificially fertilized by stripping male and female grubbys into 21 cm fingerbowls containing sea water which had been filtered through 0.45 $\mu$ filters. Fingerbowls were kept in a water bath of running sea water so that eggs were fertilized at approximately the ambient temperature and remained there dur-

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Table I

*Summary of the successful artificial fertilizations of* Myoxocephalus aenaeus *eggs.*

| Egg color | Number parents | Date of fertilization | Days to first hatch | Days when most hatched | Range in days of hatching period | Average temperature (°C) | Temperature range (°C) |
|---|---|---|---|---|---|---|---|
| Red | 2 | Dec. 23 | 42 | 42 | 42 | 4.6 | 3.0–7.0 |
| Green | 2 | Jan. 11 | 42 | 50–53 | 42–57 | 5.3 | 3.0–8.0 |
| White and red | 18 | Feb. 12 | 34 | 40–44 | 34–47 | 5.8 | 4.5–7.0 |
| White and red | 9 | Feb. 18 | 36 | 42–46 | 40–53 | 6.0 | 4.4–8.0 |

ing the entire developmental period. The water in the fingerbowls was first changed to remove excess sperm after the eggs were water hardened. From that point on, the water was changed about every three days. Initially, all fingerbowls were aerated. Later, half the fingerbowls were not aerated when it became apparent that aeration was not absolutely necessary.

Eggs and larvae in the fingerbowls were observed under a dissecting microscope and developmental times were noted. Eggs were fertilized on four different occasions (Table I). Large mortalities occurred in rearing to the young stage, and multiple fertilizations were necessary to have adequate samples for detailed descriptions of all stages. The drawings and descriptions are from all fertilizations. Samples for drawings were preserved in 5% neutralized formalin. All drawings were made with the aid of a camera lucida.

Larvae were first fed Liqua Fry and later brine shrimp nauplii.

## Results and Discussion

Field work began on 14 December 1964 when ripe males and females were collected. Ripe fish were found on the six collecting days in December, the two in January, the four in February and the two in March. No collecting was done in April, and on 19 May all seven females collected were spent. Water temperatures varied from 4° C on 14 December to 1° C in late February and early March. The water temperature was 3° C when the last ripe fish were caught on 30 March. In this area, the grubby spawns over a four-month period from December through March.

The egg of the grubby is spherical, transparent and adhesive. Small clumps of eggs have been found attached to many different substrates including vegetation, shells, stones, bryozoans and wooden traps. The color of the eggs is variable but is consistent within a single female. The eggs are light green, red, white and sometimes yellow in color. Morrow (1951) reports similar variations in color with the eggs of *Myoxocephalus octodecemspinosus.*

Table I summarizes the artificial fertilizations and incubation periods of eggs during this study.

Water-hardened eggs were spherical with an average diameter of 1.58 mm (range, 1.5–1.7 mm). The average yolk diameter was 1.46 mm (range, 1.3–1.6 mm). The egg capsule was thin and transparent with a smooth surface. The yolk had two large oil globules with an average diameter of 0.2 mm and a few smaller globules scattered throughout. The perivitelline space was narrow, about one-sixth of the egg radius (Fig. 1A).

2-cell stage: the first cleavage was meroblastic and was observed about 8½ hours after fertilization; the majority of the eggs were in this stage at 10½ hours. The two blastomeres were equal in size, raised and separated. The average egg diameter was 1.59 mm (range, 1.5–1.7 mm) and the average yolk diameter was 1.39 mm (range, 1.1–1.6 mm). The yolk was slightly corrugated with two to four large oil globules near the positive pole of the egg. The perivitelline space was one-fourth of the egg radius (Fig. 1B).

4-cell stage: the first 4-cell stage was found after 10 hours, and the majority of the eggs were in this stage at 15 hours. The four flattened blastomeres were approximately equal in size (Fig. 1C).

8-cell stage: this stage was first noticed at 16 hours and the majority of the eggs were in this stage at 20 hours (Fig. 1D).

16-cell stage: most eggs were in the 16-cell stage between 21 and 22 hours. The cells were of irregular shape, raised and in a single layer (Fig. 1E).

32-cell stage: the majority of the eggs were in this stage at 27 hours. The central cells were in a two-cell layer while the peripheral cells were in a single layer (Fig. 1F).

Multicellular stage: eggs classified as in this stage were first observed at 33 hours, and all were in this stage at 96 hours. The blastodisc remained approximately the same size during this period of multiplication of cells (Figs. 2A and 2B).

Blastula stage: blastocoele was evident and was flattened out over the yolk. Most eggs reached this stage between 98 and 196 hours (Fig. 2C).

Gastrula stage: the germ ring and the embryonic shield were evident. The germ ring was first evident at about 174 hours (7.25 days) after fertilization. The primitive streak was faint (Fig. 2D).

Early embryonic stages: the neural groove extended about one-half way around the yolk. The embryo developed visible cephalic and caudal swellings. The optic vesicles were forming and a few small oil droplets were concentrated in the caudal region (Figs. 2E and 2F).

Middle embryonic stages: embryo was elongated more than one-half way around the yolk and nine somites were evident near the caudal region. The lens of the eye was thickened and was bulging out of the optic cup. There were one to two large oil globules near the negative pole of the egg (Fig. 3A).

The embryo was in the tail-free stage. Kupffer's vesicle was evident. The divisions of the brain were differentiated. The olfactory placode, pectoral bud, auditory vesicle and notochord were present. The first movement was noted within the egg (Fig. 3B).

Late embryonic stages: retinal pigment was first seen and the lens of the eye was pronounced. Finfold was evident. Heartbeat was first seen. About 21 somites were seen over one-half of the body. Two large oil globules were near the cephalic region and a few smaller ones near the caudal region (Fig. 3C).

There was a continuing increase in the size of the embryo with a gradual decrease in the size of the yolk sac (Fig. 3D). On the lateral flexion, the tip of the tail passes over the hindbrain. The heart was situated in the frontal concavity of the yolk sac. The otoliths were visible and the pectoral fins curved. The rudiment of the lower jaw was present and the head more flattened. The embryo exhibited much twitching at this stage.

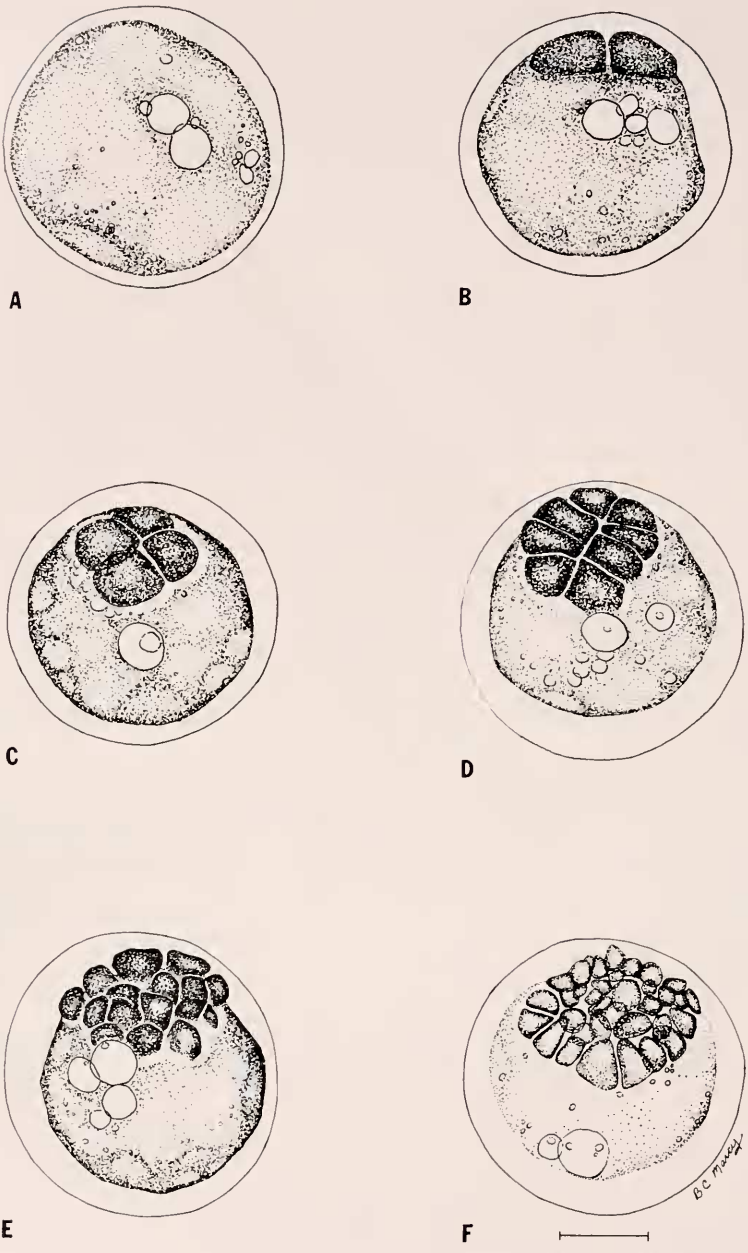


FIGURE 1. Early development of the eggs of the grubby, *Myoxocephalus aenaeus*, artificially propagated in the laboratory: A) unfertilized water-hardened egg, 1.58 mm; B) fertilized egg, 1.59 mm, two-cell stage (12 hr, 20 min); C) 4-cell stage, 1.60 mm (15 hr, 50 min); D) 8-cell stage, 1.61 mm (16 hr, 55 min); E) 16-cell stage, 1.54 mm (21 hr, 10 min); F) 32-cell stage, 1.60 mm (27 hr, 40 min), scale = 0.5 mm. Measurements refer to mean egg capsule diameters.

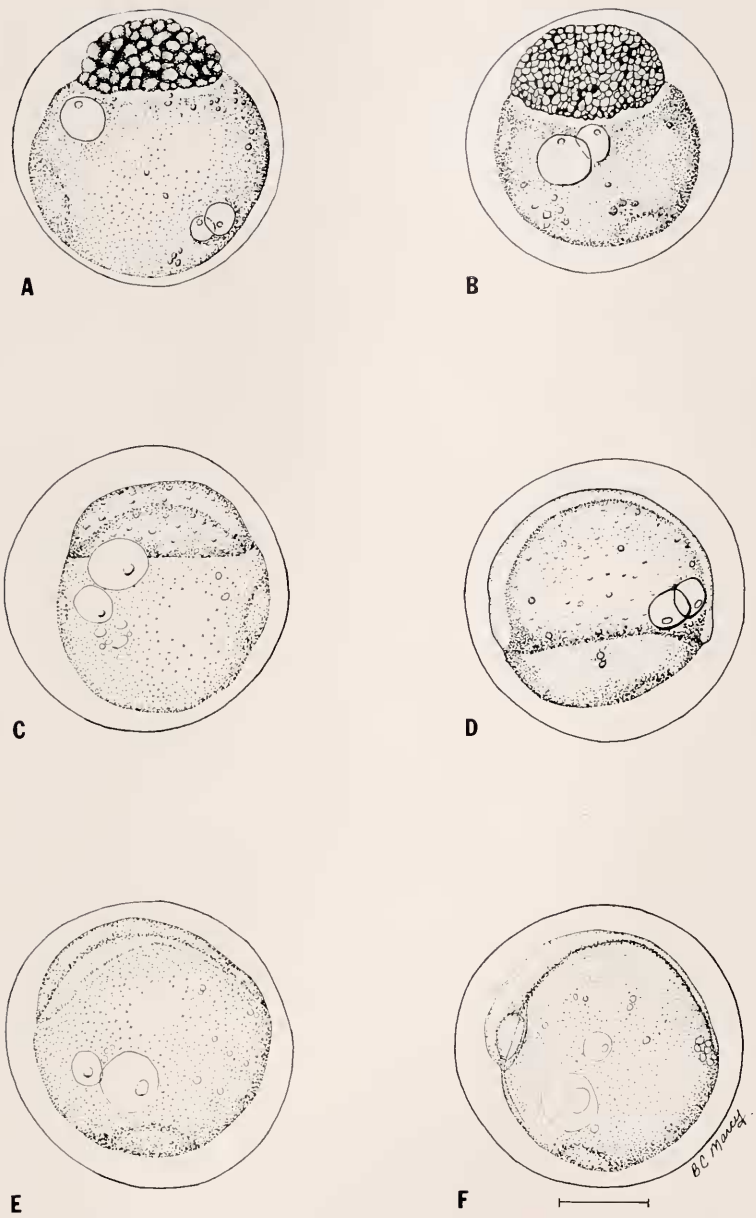


FIGURE 2. Development of the eggs of the grubby, *Myoxocephalus aenaeus*, artificially propagated in the laboratory: A-B) 64-cell to multicellular stage, 1.60 and 1.57 mm (33–98 hr); C) blastula stage, 1.53 mm (196 hr—8 days); D) gastrula stage, 1.53 mm (196 hr—8 days); E-F) early embryonic stages, 1.60 mm (189–246 hr—7.8 to 10.3 days), scale = 0.5 mm. Measurements refer to mean egg capsule diameters.

At this stage the tail was now curved around the head and the pectoral fins were raised above the yolk sac (Fig. 3E). The first evidence of pigmentation was a sprinkling of contracted melanophores on the dorsal side of the head near the optic vesicles. Stellate melanophores were next evident between the yolk sac and the body, posterior to the pectoral fins. The anal vent was now apparent and the eyes appeared to have lost the deep fissure.

The rays in the caudal fin were faintly seen (Fig. 3F). The lower jaw was more developed and the mouth was open. The melanophores on the surface of the yolk were expanding with a band running diagonally from the anal vent to below the head. Most embryos showed seven to ten melanophores between the auditory vesicles on the dorsal surface. The circulatory system was noticeable along the length of the tail. There was much twitching and head extension of the embryo.

Prehatching stage: the embryo occupied almost the entire egg capsule and was able to make full revolutions within the egg. The tail was wrapped almost completely around the body. The pectoral fins occasionally showed fluttering movements between long periods of quiescence. There was now a single large oil globule near the head. The margin of the operculum appeared well defined. Evenly spaced melanophores extended from behind the vent along the ventral line of the tail. Dense melanophores were present on the dorsal surface of the yolk sac (Fig. 4A).

Most prolarvae hatched between 40 and 44 days (Fig. 4B). Most emerged from the egg head first but a few were observed to emerge tail first. The prolarvae ranged between 4.7 and 6.3 mm TL (mean, 5.4 mm). The yolk sac measured 0.9 mm. As in the egg stages, the large oil globule contained a small bubble. The eye was darkly pigmented. Additional stellate chromatophores were present and scattered in two bands over the ventral yolk sac with a large concentration along the intestine and a series of 20 to 24 spots along the lower ventral line of the tail. The larvae had 32 myomeres. The dorsal finfold was continuous with a lunate caudal portion. The incipient rays of the caudal fin were faintly seen and the lines of ossification were present along the notochord. The auditory vesicles bulged above the eye and the mouth was still not well developed.

The yolk sac and oil globule were absorbed about five days after hatching (6.1 mm TL) (Fig. 4C). Large dark contracted chromatophores were present over the gut area with 30 to 34 spots along the lower ventral line of the tail. A few chromatophores extended onto the finfold in the caudal region. There were large expanded chromatophores at the base of the pectoral fin and a few scattered behind the auditory vesicles. The mouth was fully developed and functional. Larvae now approached the brine shrimp nauplii, coiled their tails, struck and settled to the bottom for a short rest period. Two head spines were developed on the dorsal bulge of the auditory vesicles and four were seen on each side of the head along the operculum. The postlarvae had 32 myomeres and the finfold was smooth and continuous.

In a 14-day-old larva (6.8 mm), the finfold was more ragged and the first incipient rays of the dorsal fin were present. Chromatophores were present along the developing caudal and pectoral fins. The latter had prominent rays. Four gill arches were noticeable. The chromatophores along the intestine were dense, contracted and easily observed with the naked eye. Brown to orange stellate

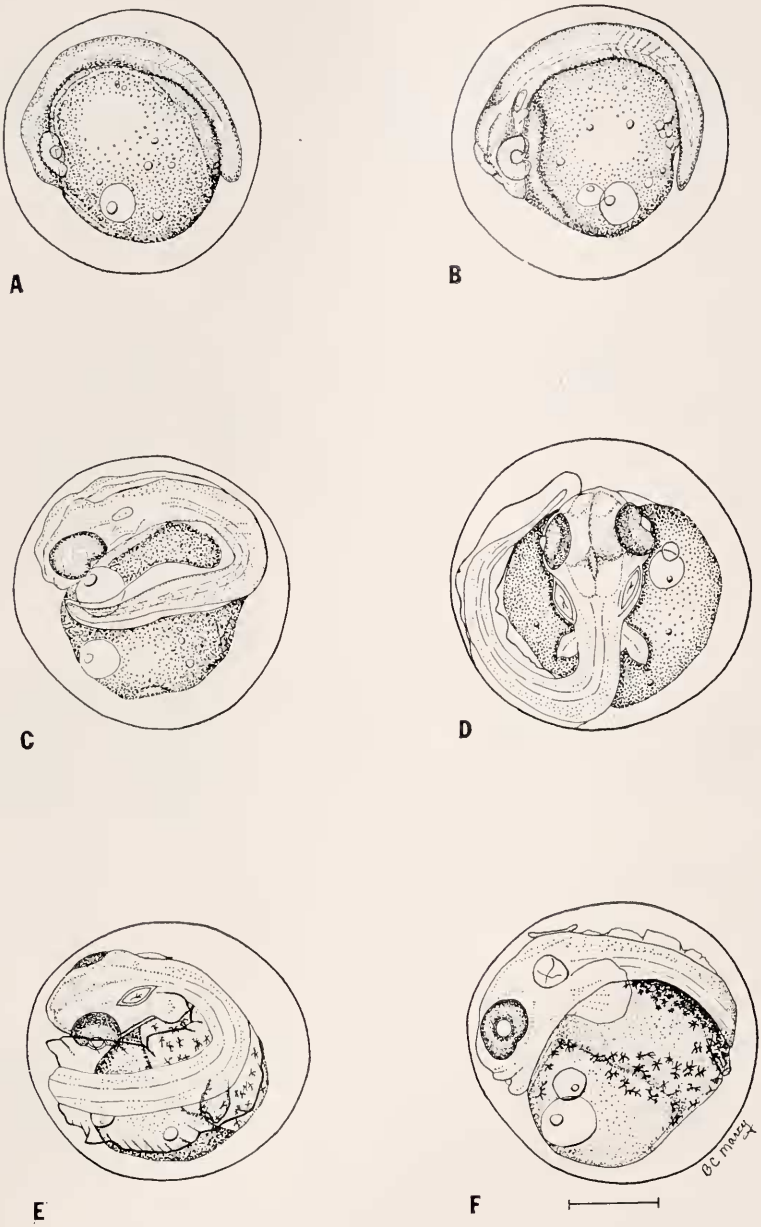


FIGURE 3. Later development of the eggs of the grubby, *Myoxocephalus aenaeus*, artificially propagated in the laboratory: A) developing embryo, 1.60 mm (325 hr—13.5 days); B) developing embryo, 1.57 mm (350 hr—14.6 days); C) developing embryo, 1.60 mm (415 hr—17.3 days); D) developing embryo, 1.67 mm (552 hr—23 days); E) late developing embryo, 1.60 mm (605 hr—25.2 days); F) late developing embryo, 1.60 mm (725 hr—30.2 days), scale = 0.5 mm. Measurements refer to mean egg capsule diameters.

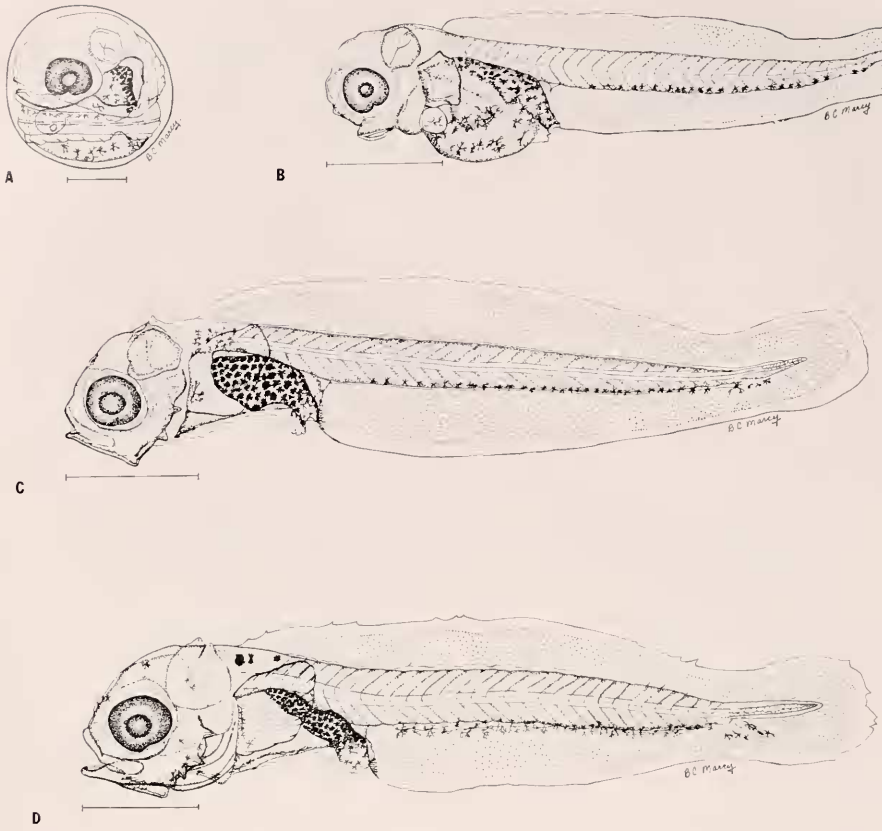


FIGURE 4. Pre-hatch embryo, prolarval and early postlarval stages of the grubby, *Myoxocephalus aenaeus*, artificially propagated in the laboratory: A) pre-hatch, well developed embryo, 1.65 mm (960–1,056 hr, 40–44 days), scale = 0.5 mm; B) newly hatched prolarva 5.4 mm TL, scale = 1 mm; C) postlarva, 6.1 mm TL (5 days old), scale = 1 mm; D) postlarva, 6.8 mm TL (14 days old), scale = 1 mm. Measurements refer to mean egg capsule diameter and mean total length of larvae.

chromatophores were evident above the pectoral fin and along the top of the head, the cleithrum, and the preopercle at the base of each spine (Fig. 4D).

Pectoral fins were elongating on the dorsal side and an anlage of the dorsal spines was developing along the dorsal line of the tail (Fig. 5A). The caudal fin rays were distinctly bifurcate. Five spines were now evident along the operculum. Two spines were present on each side of the head above and joined to the auditory vesicles. The chromatophores along the the stomach and intestine were almost continuous with fewer toward the vent. Large stellate chromatophores were more prominent on the head with dark vertical barring appearing posterior to the auditory vesicles.

The dorsal head spine appeared as two distinct spines on each side (Fig. 5B). The anal fin rays were developing with stellate chromatophores located along the ventral line of the tail. The ventral fin was now evident and the pectoral fin was

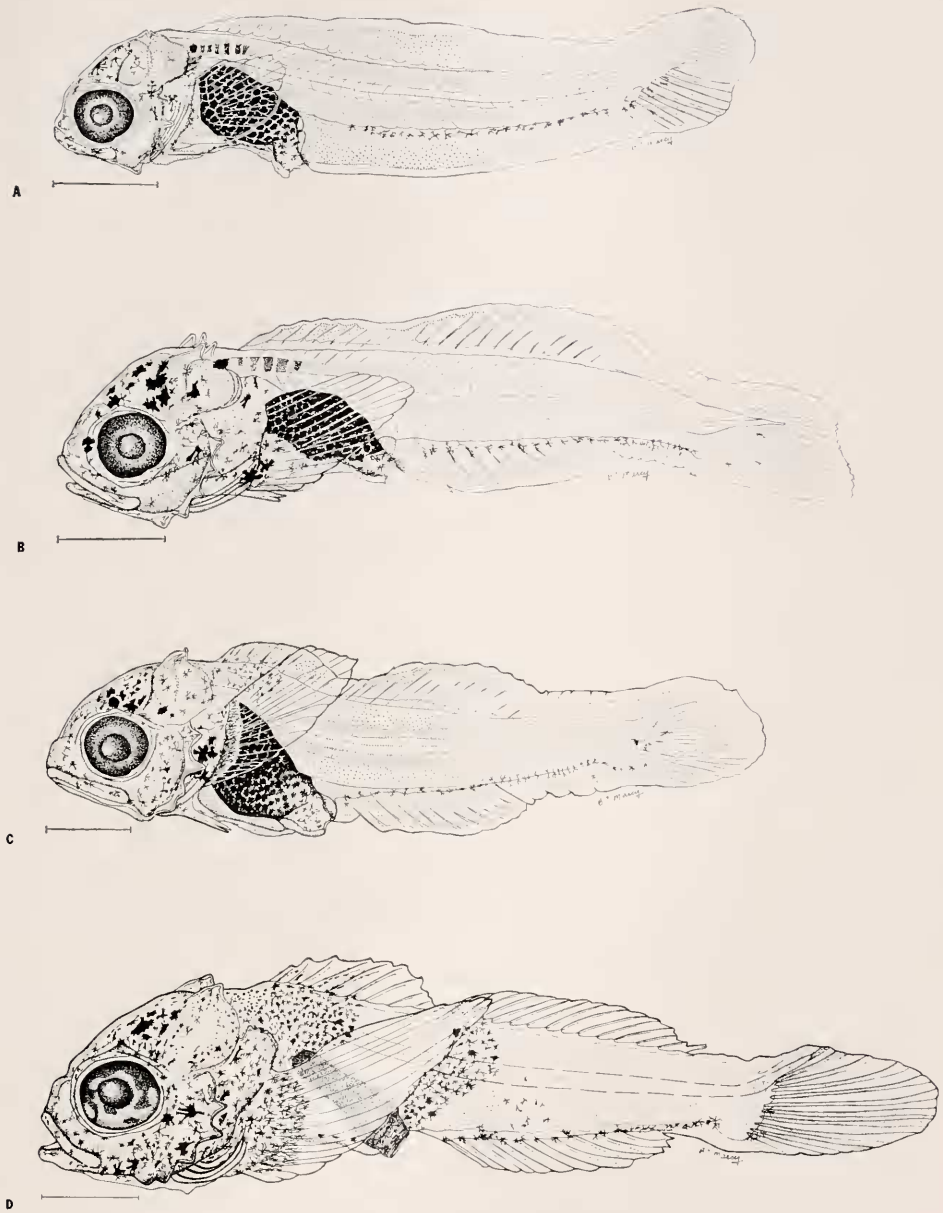


FIGURE 5. Later postlarval and young stages of the grubby, *Myoxocephalus aenaeus*, artificially propagated in the laboratory: A) late postlarva, 6.8 mm TL (22 days old), scale = 1 mm; B) late postlarva, 7.5 mm TL (30 days old), scale = 1 mm; C) postlarva prior to transformation to young, 8.5 mm TL (45 days old), scale = 1 mm; D) transformed young with adult characteristics, 9.2 mm TL (55 days after hatching), scale = 1 mm. Measurements refer to mean total length of larvae and young.

becoming fan-like. The finfold was continous but irregular. Large dark chromatophores appeared above the eye, at the base of the pectoral fin and below the dorsal fin.

In a 45-day-old larva (8.5 mm), the fins, except for the dorsal, were still incomplete. The pectoral fin extended past the dorsal fin. The two dorsal head spines on each side overlapped each other and appeared as one large structure. The dark pigment bars above the eye had transformed into stellate chromatophores extending up into the first dorsal fin, and there was further pigmentation in the head area.

The grubby is transformed from the larval stage at approximately 9 mm TL (Fig. 5D), approximately 55 days after hatching. The first dorsal fin had nine spines and was shorter (front to rear) than the second dorsal of 14 rays. The anal fin had 11 rays. The urostyle had turned dorsally. There were now six spines along the operculum and the two head spines noted in the previous two stages had become one large spine covered by tissue. There was development of a pair of spines between the nostrils. The head was covered with large brown stellate chromatophores. The intestine and stomach appeared solid dark brown. Bands of chromatophores were forming diagonally from ventral to dorsal surfaces along the body. Pigmentation along the ventral line of the tail was still regular.

Young were raised in the laboratory until 108 days after hatching (12.8–21.0 mm TL). Growth was most rapid between 55 and 108 days. The head became more flattened and the snout more pointed with head spines becoming larger and well defined. The body became covered with dark shading or irregular barrings as the young took on typical adult coloration.

All original drawings were made by B. C. Marcy, Jr.

## Summary

1. The grubby spawns over the four-month period of December through March in the Mystic River, Connecticut. The spherical, adhesive eggs are light green, red, white, and sometimes yellow in color and are found in small clumps attached to many different substrates.

2. Eggs were artificially fertilized on four occasions over a two-month period. The average water temperatures during development ranged from 4.6 to 6.0° C. The first cleavage occurred between $8\frac{1}{2}$ and $10\frac{1}{2}$ hours after fertilization and progressed to the multicellular stage at 33 to 96 hours. Gastrulation was first observed at about 174 hours, and the total developmental period varied from 34 to 57 days with most hatching between 40 and 44 days.

3. Prolarvae ranged between 4.7 and 6.3 mm TL, and the yolk sacs were absorbed in about five days. All fins were developed in approximately 55 days. During the period between 55 and 108 days, pigmentation was completed and the young took on the typical adult coloration.

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